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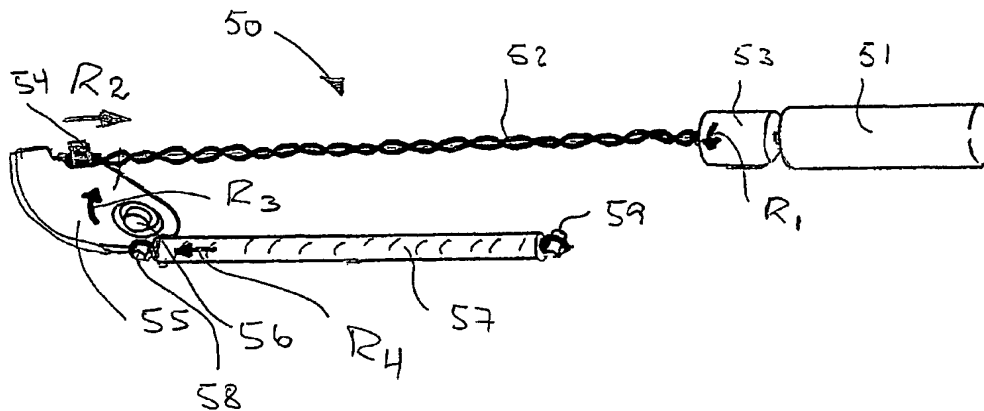
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(54) Title: AN ACTUATOR



(57) Abstract: An actuator 50 comprising a rotational motor 51 and one or more elongate, flexible elements 51 such as a string, a filament, a strip, a ribbon and combinations thereof, the one or more elements being attached to the motor for rotation thereby and to a displaceable body 55, such that rotation of the motor twists the one or more elements and shortens the overall length thereof so that the displaceable body is displaced by the shortened element or elements, a biasing means such as for instance a spring 57 being connected to the displaceable element and/or the elements such that shortening of the elements takes place against a biasing force exerted by the biasing means, and where the body is fixedly attached to the one or more elements at one end of the one or more elements such that the end is prevented from rotating under the influence of the twisting force applied by the motor.

WO 2006/105794 A1

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AN ACTUATOR

The present invention relates to a method of dispensing liquid medicine comprising the steps of providing a wearable, disposable dispensing device
5 comprising a syringe having a cylinder and a plunger displaceable in said syringe cylinder for pressing medicine out of said syringe cylinder and a drive mechanism connected to said plunger for displacing said plunger in said cylinder, and an electrical motor connected to a battery and to said drive
10 mechanism for providing a rotary force to said driving mechanism for displacing said plunger, displacing said plunger a certain distance in connection with a cycle of said driving mechanism.

Methods of this type are known, wherein the electrical motor is controlled by a control means so as to carry out a certain number of revolutions for each cycle
15 corresponding to the desired distance of displacement of the plunger.

In connection with such methods it is important that no more than the predetermined amount of medicine be dispensed per cycle as otherwise life threatening dosages may be dispensed.
20

When utilizing an electrical motor, a short circuit can entail that the motor does not stop after the predetermined number of revolutions or that the motor starts by itself.

25 Security means have been suggested to ensure that the predetermined dosage is not exceeded, for instance monitoring the amount of liquid dispensed per cycle or monitoring the displacement distance of the plunger or the amount of revolutions of the motor per cycle with interruption means being activated if the monitored elements exceed a certain value.

30 There exists a need for a simple and fail-safe method to avoid over-dosage of medicine. One main object of the invention is to meet this need.

According to the invention this object is achieved by the cycle comprising rotating said electrical motor in a first direction of rotation and subsequently rotating said electrical motor in the opposite direction of rotation.

- 5 Hereby, any short-circuit of the motor will not entail continued rotation of the motor in one direction with ensuing continued dispensing of medicine.

The invention furthermore relates to a wearable, disposable medicine dispensing device comprising:

- 10 - a syringe having cylinder and a plunger displaceable in the syringe cylinder for pressing medicine out of said syringe cylinder,
- a drive mechanism connected to said plunger for displacing said plunger in said cylinder, and
- an electrical motor connected to a battery and to said drive mechanism for
15 providing a rotary force to said driving mechanism for displacing said plunger, and
- control means adapted for repeatedly reversing the direction of rotation of said electrical motor.

- 20 In a further aspect, the present invention relates to an actuator comprising:
- a rotational motor.
- one or more elongate, flexible elements such as a string, a filament, a strip, a ribbon and combinations thereof, said one or more elements being attached to said motor for rotation thereby and to a displaceable body,
25 such that rotation of said motor twists said one or more elements and shortens the overall length thereof so that said displaceable body is displaced by the shortened element or elements.

- Such an actuator according to the invention may be used in connection with
30 medicine dispensing devices, but also in any application where a rotational force or movement is to be utilized to displace a body.

In the following the invention will be described more in detail in connection with two embodiments shown, solely by way of example, in the accompanying drawings, where

- 5 Fig. 1 shows a first embodiment of a device according to the invention seen in perspective and with the top part of the housing removed,

Fig. 2 shows a perspective view of the drive mechanism of the device according to the invention in Fig. 1,

10

Fig. 3 is an exploded view of some of the drive mechanism elements of the device in Fig. 1, and

- 15 Figs. 4 and 5 are views corresponding to Fig. 2 with the drive mechanism in other positions, and

Figs. 6-9 are views of a second embodiment of the device according to the invention corresponding to Figs. 1, 2, 4 and 5, respectively.

- 20 Figs. 10-14 show a perspective view of a third embodiment of the device according to the invention in different sequential states during a first half cycle during rotation of the electrical motor in a first direction of rotation,

- 25 Figs. 15a, b and c are views of some of the drive mechanism elements of the device in Figs. 10-14 in different states during the cycle.

Fig. 16. is a schematic perspective view of a first embodiment of an actuator according to the invention, and

- 30 Figs. 17a-b very schematically show a second embodiment of an actuator according to the invention at two different phases of an actuation cycle.

Referring now to Figs. 1-5, a wearable disposable dispensing device for medicine referred to generally by the numeral 1 and of the type described in WO 2004/041330 and WO 2004/065412, the disclosure of which is hereby incorporated herein by reference, comprises a housing 2, where only the
5 bottom half is shown for the sake of clarity, a cylindrical medicine container or carpule 3 having at one end a silicone body for receiving a catheter for dispensing medicine from the interior of the carpule to a human body and being open at the opposite end to receive a flexible piston rod 5 for displacing an internal not shown plunger or piston in the carpule 3 for forcing medicine out
10 through a catheter needle assembly connected to the silicone body 4.

The flexible piston 5 is composed of segments hinged together and outwardly threaded guided by a rail 6 received in recesses in each of the segments of the rod 5. The not shown outward threads of the segments of the flexible piston rod
15 5 engage in a thread 8 of ratchet wheel 7 having teeth 9 along the periphery thereof. An electrical motor 10 electrically connected to a battery 11 and control means 12 is provided with a gear 13 meshing with a gear 14 attached to an outwardly threaded spindle or shaft 15 received in an inwardly threaded nut 16 attached a plate 17 provided with two slits 18 and 19, extending parallel to the
20 axis of said spindle 15 and a third slit 20, extending at an angle to said axis. Two fixedly arranged pins 21 and 22 are received in the slits 18 and 19, respectively such that the pins serve as guides to the to and fro displacement of the plate 17 by means of the spindle 15 when the electrical motor 10 rotates first in one directional rotation and thereafter in the opposite directional rotation.

25

A protuberance 23 is arranged on the plate 17 to co-operate with two end stop contacts 24 and 25 electrically connected to the control means 12 for reversing the direction of rotation of the electrical motor when the protuberance 23 contacts one of the end stop contacts 24 or 25. A pawl 26 is attached to a
30 pivotable elongated body 27 having a pin 28 for being received in the oblique slit 20 and a hole 29 for receiving the pin 21 such that the body 27 is pivotable around the pin 21. A ratchet 30 is fixedly attached to the housing 2 by means of a pin 31 and is located so as to engage the teeth 9 of the ratchet wheel 7. The

pawl 26 is displaceable from a retracted position where it does not engage the teeth 9 of the ratchet wheel 7 and in an engaged position in which it engages the teeth of the ratchet wheel and rotates the ratchet wheel in a clockwise direction.

5

The displacement of the pawl 26 between the two positions indicated above takes place by the linear displacement of the plate 17. When the plate 17 is displaced in the direction from the end stop contact 24 to the end stop contact 25, the oblique slit 20 urges the pin 28 of the elongated body 27 in a direction
10 away from the carpule 3 such that the elongated body 27 pivots around the pin 21 in a clockwise direction, whereby the pawl 26 is moved in towards its retracted position relative to the ratchet wheel 7. When the protuberance 23 on the plate 17 contacts the end stop contact 25, the directional rotation of the motor 10 is reversed and the plate 17 is displaced in the direction from the end
15 stop contact 25 towards the end stop contact 24, whereby the oblique slit 20 forces the pin 28 towards the carpule 3, whereby the elongated body 27 is forced to rotate in a counterclockwise direction whereby the pawl 26 is brought into contact with one of the teeth 9 of the ratchet wheel and rotates the ratchet wheel in a clockwise direction, while the ratchet rides over one of the other
20 teeth 9 for locking the ratchet wheel against rotation in the counterclockwise direction.

Thus, during one cycle of rotation in one direction and the opposite direction of the electrical motor 10, the ratchet wheel 7 will be advanced by one tooth
25 corresponding to one displacement of the pawl 26 from the retracted position thereof the engaged position thereof.

Referring now to Figs. 6-9, in this embodiment a coil spring 40 is attached to a pin 41 fixedly attached to the housing 2 and a pin 42 fixedly attached to the
30 plate 17.

When the plate 17 is moved in the direction from end contact 24 towards the end contact 25, the spring 40 is tension, and when the plate 17 moves back in

a direction from the end stop contact 25 towards the end stop contact 24 after reversion of the direction of rotation of the motor 10, the spring 40 will be relaxed and exert a force in the same direction as the motor 10 on the plate 17 and thus reinforcing the force available to rotate the ratchet wheel 7.

5

Referring now to Figs. 10-15, the electrical motor 10 is electrically connected to a battery and control means and the axle of the motor is connected to a pair of twisted strings 35 or a band or similar device, which reduces its length when twisted and increases its length when untwisted, said length variation being
10 provided by the rotation of the motor, i.e. the device is connected to the rotating axle of the motor at one end and connected to a pivotable body 78 at the opposite end. The pivotable body is provided with an extension 78a comprising a pawl 74 arranged to engage the teeth 9 on the ratchet wheel 7, as indicated in Figs. 15a, 15b, 15c, whereby the pivoting of the pivotable body 78 provides a
15 rotation of the ratchet wheel 7. A second pawl mechanism 72, 84 is provided to prevent rotation of the ratchet wheel 7 in the opposite direction, again as shown in Figs. 15a-15c.

The displacement of the pawl 74 between the two positions indicated in Figs.
20 15a and 15b is provided by the reduction of the length of the twisted strings 35 by rotation of the motor and the displacement in the opposite direction is provided by the spring 40 during extension of the twisted strings 35 provided by rotation of the motor in the opposite direction, whereafter further rotation in this direction again reduces the length of the twisted strings 35, whereby a
25 complete cycle of rotation in one direction of the motor provides a movement of the pivotable body from the position shown in Fig. 15a to the position shown in Fig. 15b and back to the position shown in Fig. 15a, this movement being provided by the twisted strings 35 being untwisted and twisted in the opposite direction during rotation of the motor in one direction. Thus, the rotation of the
30 motor in one direction of rotation provides a full stroke for the pivotable body and thus the pawl mechanism moving the ratchet wheel one step forward and the following rotation of the motor in an opposite direction of rotation provides a further full stroke of the pivotable body and the pawl mechanism.

Thus, during one cycle of rotation in one direction and the opposite direction of the electrical motor 10, the ratchet wheel 7 will be advanced by two teeth corresponding to two displacements of the pawl 74. The pivotable body 78
5 comprises a protuberance 78a which co-operates with two end stop contacts 85a and 85b electrically connected to the control means for controlling the reversal of the direction of rotation of the electrical motor when the protuberance 78a contacts the end stop contact 85a. Due to the fact that the twisted strings 35 can only provide a pulling force on the pivotable body 78, a
10 spring 40 is connected to the pivotable body to provide the movement in the direction shown by the arrow in Fig. 10.

In the embodiment shown in the figures spring 40 is a coil spring, however, other types of springs, such as a rod spring could be provided for this purpose.
15

Referring now to Fig. 16, an actuator according to the invention is referred to generally by the numeral 50 and is identical to the actuator shown in Figs. 10-14. This actuator may be employed for any use requiring transformation of a rotation to a linear movement or a rotational force to a linear force.
20

A rotation motor 51 is attached to a pair of elongate, flexible elements such as strings or filaments 52 by means of a rotational body 53 that may or may not function as a fly wheel. The elements 52 are attached to a pin 54 on a pivotable plate. Rotation of the motor in the direction R1 will twist the strings 52 such
25 that the length thereof is shortened until the pin 54 is displaced linearly in the direction R2 whereby the plate 55 is rotated around pivot 56 in the direction R3. A tension spring 57 is attached to plate 55 at pin 58 and to a not shown frame at pin 59.

30 Rotation of the plate 55 will expand the spring 57 in the direction R4 against the spring force thereof.

Rotation of the motor 51 in the direction opposite R1 will at first untwist the elements 52 whereby the length thereof becomes larger with the consequence that the spring 57 rotates the plate 55 in the direction opposite R3.

- 5 Further rotation of the motor 51 in the direction opposite R1 will twist the elements 52 again and eventually exert a force on said pin 54 in direction R2 again, the direction of rotation being subsequently reversed again and the cycle starts anew..
- 10 In case, a smaller interval is desired between each turn of the plate 55 in the direction R3, the motor 51 may reverse direction of rotation as soon the elements 52 have become untwisted to an extent that the spring 57 has pivoted the plate a certain distance in the direction opposite R3.
- 15 Reference is now made to Figs. 17a -17b, where a motor 51 is attached to both opposed ends of an elongate, flexible element such as a string or filament 52 by means of a rotational body 53 that may or may not function as a fly wheel. The element 52 forms a loop 60 within which are located two bodies 61 and 62.
- 20 The body 61 is displaceable along a groove 63 in which a pin 64 of the body is slideably received. A spring 65 is attached to the displaceable body 61 such that displacement of said body 61 in the direction R5 takes place against the biasing force exerted by the spring 65.
- 25 The other body 62 is fixedly arranged such that when twisting of the element 52 by rotation of the motor 51 takes place the loop 60 is reduced in size as seen in Fig. 17b and the displaceable body 61 is forced towards the fixed body 62 along the groove 63 and against the spring force of the spring 65.
- 30 When the rotational direction of the motor is reversed so that it rotates in the direction R7, the element 52 will be untwisted, the loop 60 will enlarge and the spring 65 will displace the body in the direction R6.

Although the groove is shown extending substantially linearly, it may obviously be curved and extend at different angles to the axis of the motor.

The body 61 may be attached to a multitude of different driving or transmission
5 mechanisms, for example the ratchet and pawl mechanisms shown in Figs. 1-9.

A displaceable body should be taken to mean any body that can change position either by linear motion, curved motion, rotative motion, etc. and any
10 combination thereof under the influence of a force applied to a point on or in said body.

Displacement should likewise be taken to mean any change in position resulting from linear motion, curved motion, rotative motion, etc. and any
15 combination thereof.

CLAIMS

1. An actuator comprising:

5 - a rotational motor.

- one or more elongate, flexible elements such as a string, a filament, a strip, a ribbon and combinations thereof, said one or more elements being attached to said motor for rotation thereby and to a displaceable body,

10 such that rotation of said motor twists said one or more elements and shortens the overall length thereof so that said displaceable body is displaced by the shortened element or elements.

2. An actuator according to claim 1, wherein a biasing means such as for instance a spring is connected to said displaceable element and/or said
15 elements such that shortening of said elements takes place against a biasing force exerted by said biasing means.

3. An actuator according to claim 1 or 2, wherein said body is fixedly attached to said one or more elements at one end of said one or more elements such
20 that said end is prevented from rotating under the influence of the twisting force applied by said motor.

4. An actuator according to claim 1 or 2, wherein said at least one elongate, flexible element forms a loop such that both opposed ends of said element or
25 elements are attached to said motor, said a portion of said displaceable body being placed within said loop.

5. An actuator according to claim 4, wherein a further body is placed within said loop such that twisting of said one or more elements by said motor shortens
30 said loop whereby said one or more elements exerts a force on said displaceable body.

6. An actuator according to claim 1 or 2, wherein at least one first of said elements is attached to said displaceable body, and at least one second of said elements is attached to a second body spaced from displaceable body such that twisting of said first and second elements around one another by rotation
5 of said motor exerts a force on said displaceable body.

7. A method of dispensing liquid medicine comprising the steps of:

- 10 - providing a wearable, disposable dispensing device comprising a syringe having a cylinder and a plunger displaceable in said syringe cylinder for pressing medicine out of said syringe cylinder, an actuator according to any of the claims 1-4, and a drive mechanism connected to said actuator and to said plunger for displacing said plunger in said cylinder,
- 15 - displacing said plunger a certain distance in connection with a cycle of said actuator comprising rotating said motor in a first direction of rotation and subsequently rotating said motor in the opposite direction of rotation.

8. A wearable, disposable medicine dispensing device comprising:

- 20 - a syringe having cylinder and a plunger displaceable in the syringe cylinder for pressing medicine out of said syringe cylinder,
- a drive mechanism connected to said plunger for displacing said plunger in said cylinder, and
- an actuator according to any of the claims 1-4 connected to said drive mechanism, and
- 25 - control means adapted for repeatedly reversing the direction of rotation of said electrical motor.

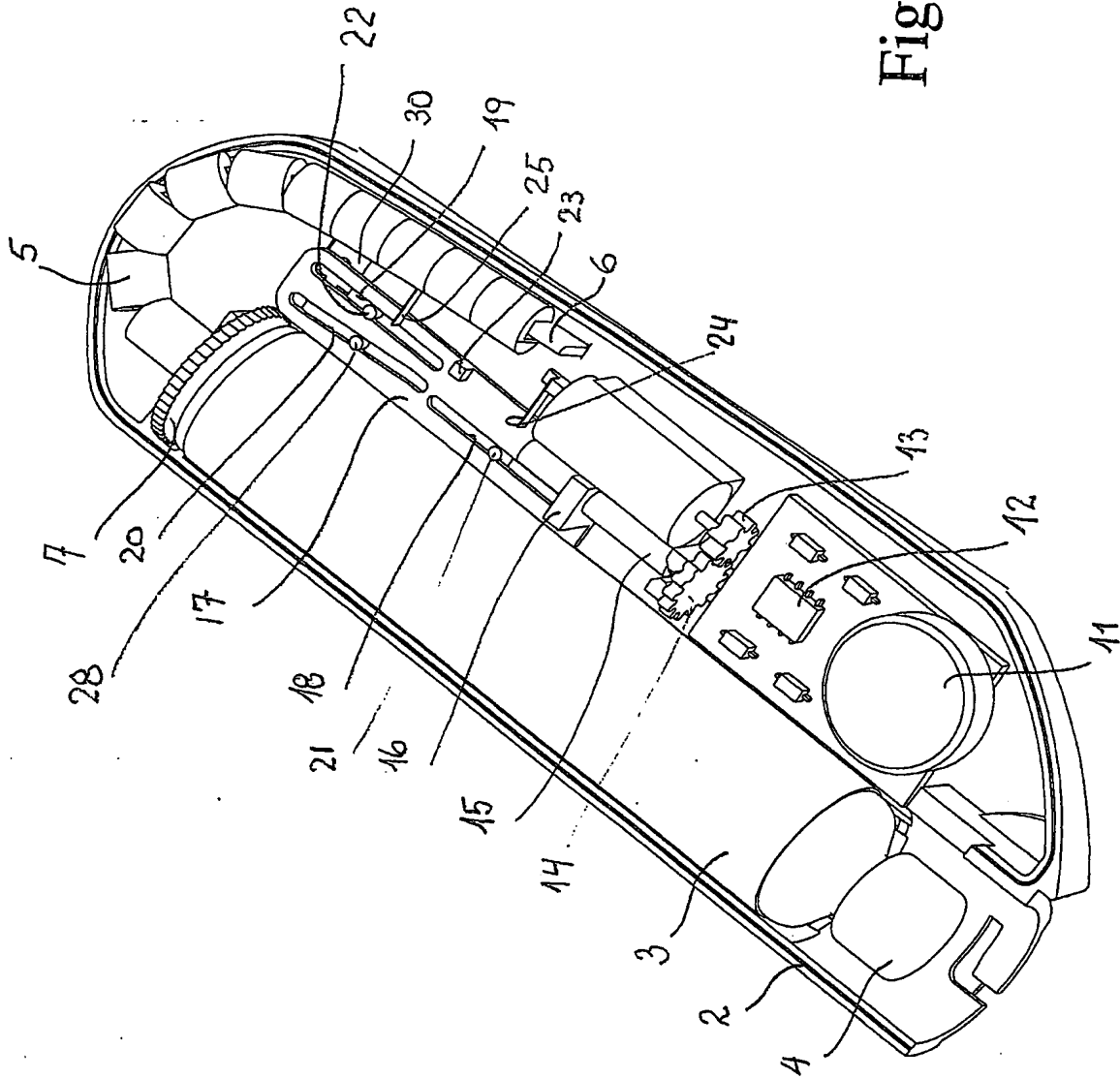


Fig. 1

2/16

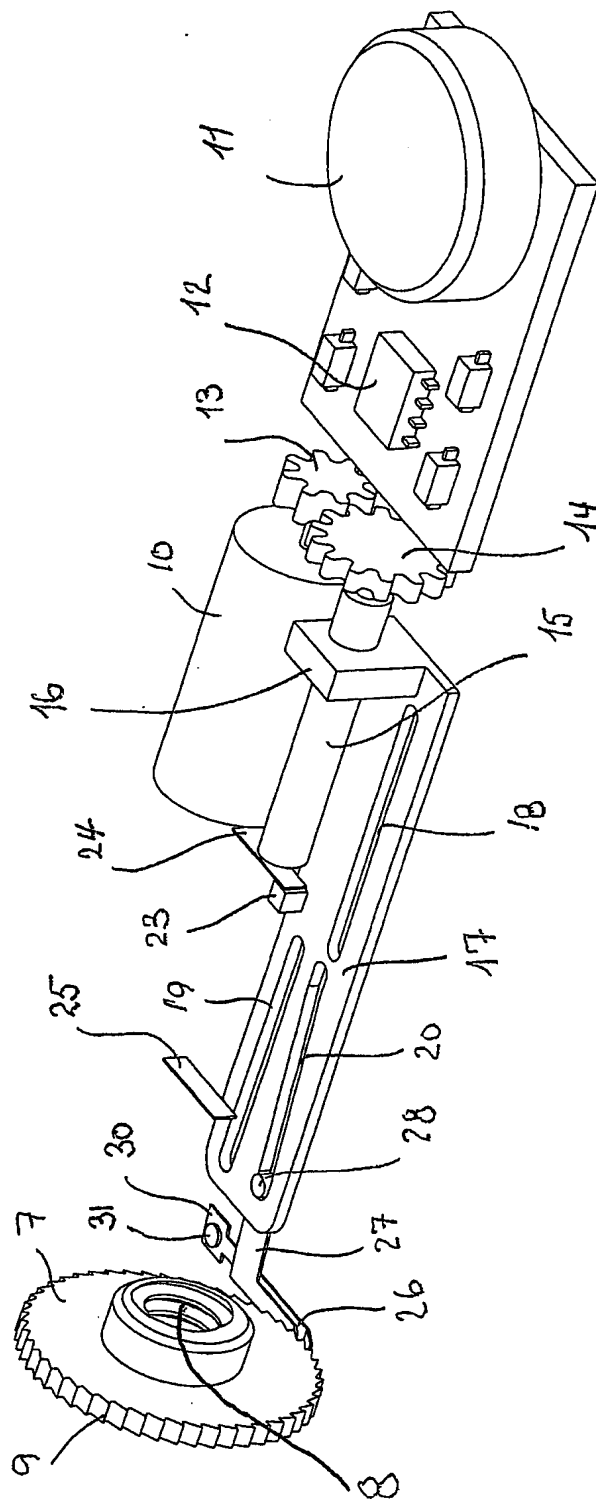


Fig. 2

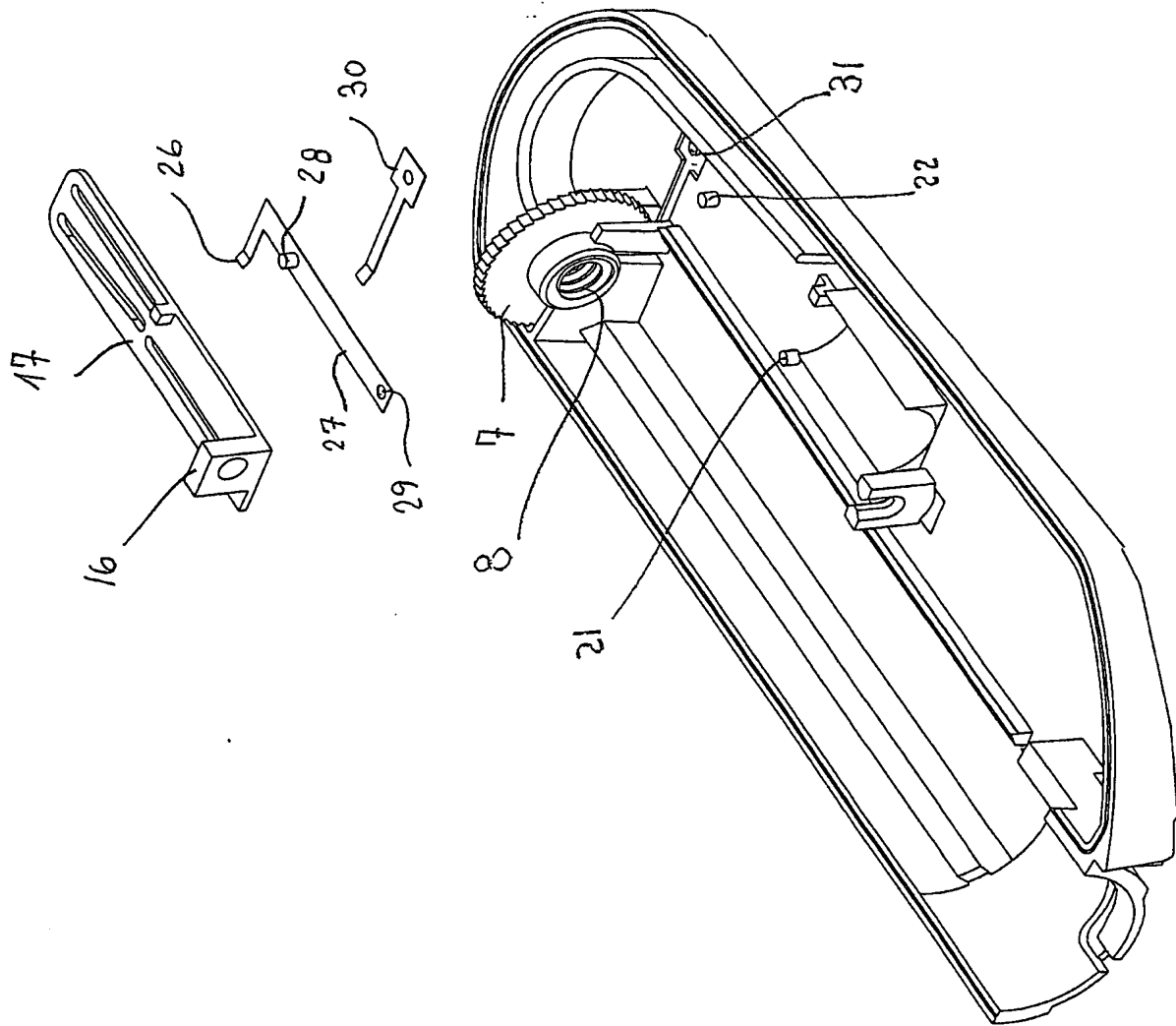


Fig. 3

4/16

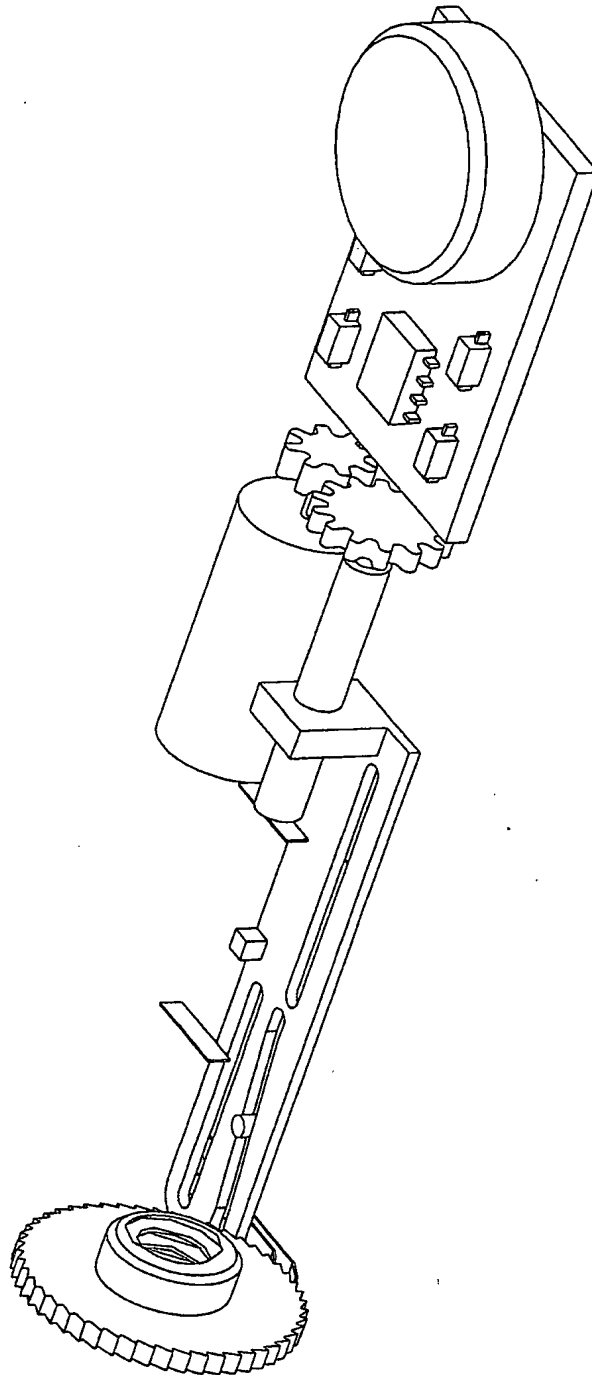


Fig. 4

5/16

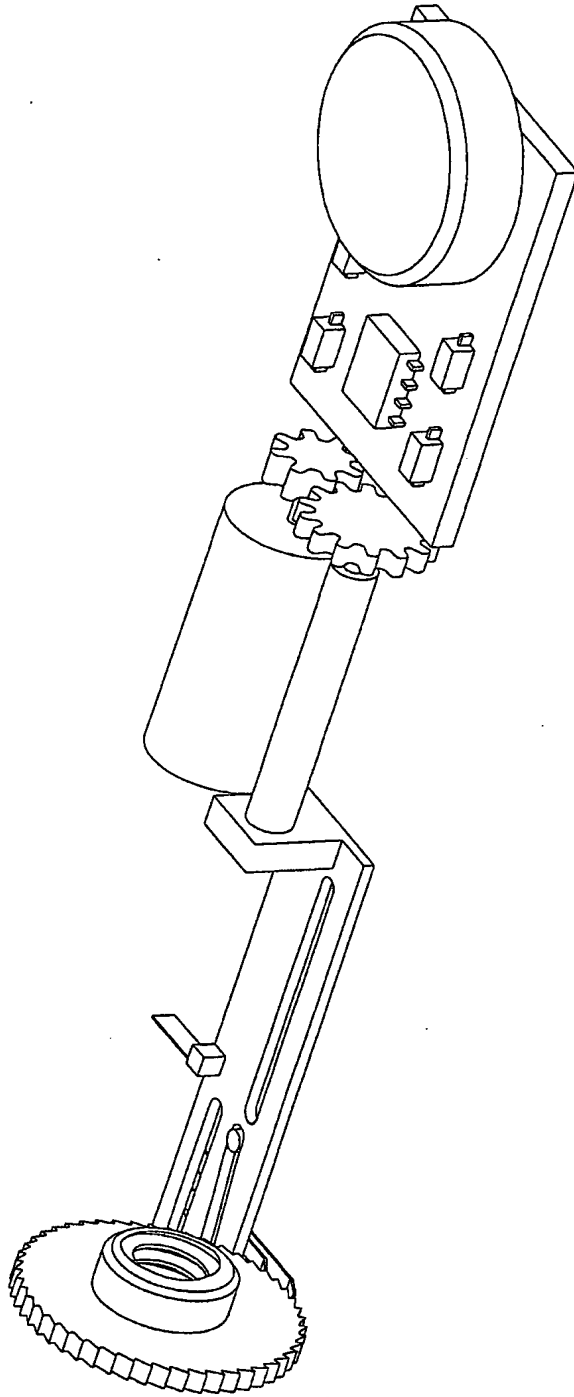
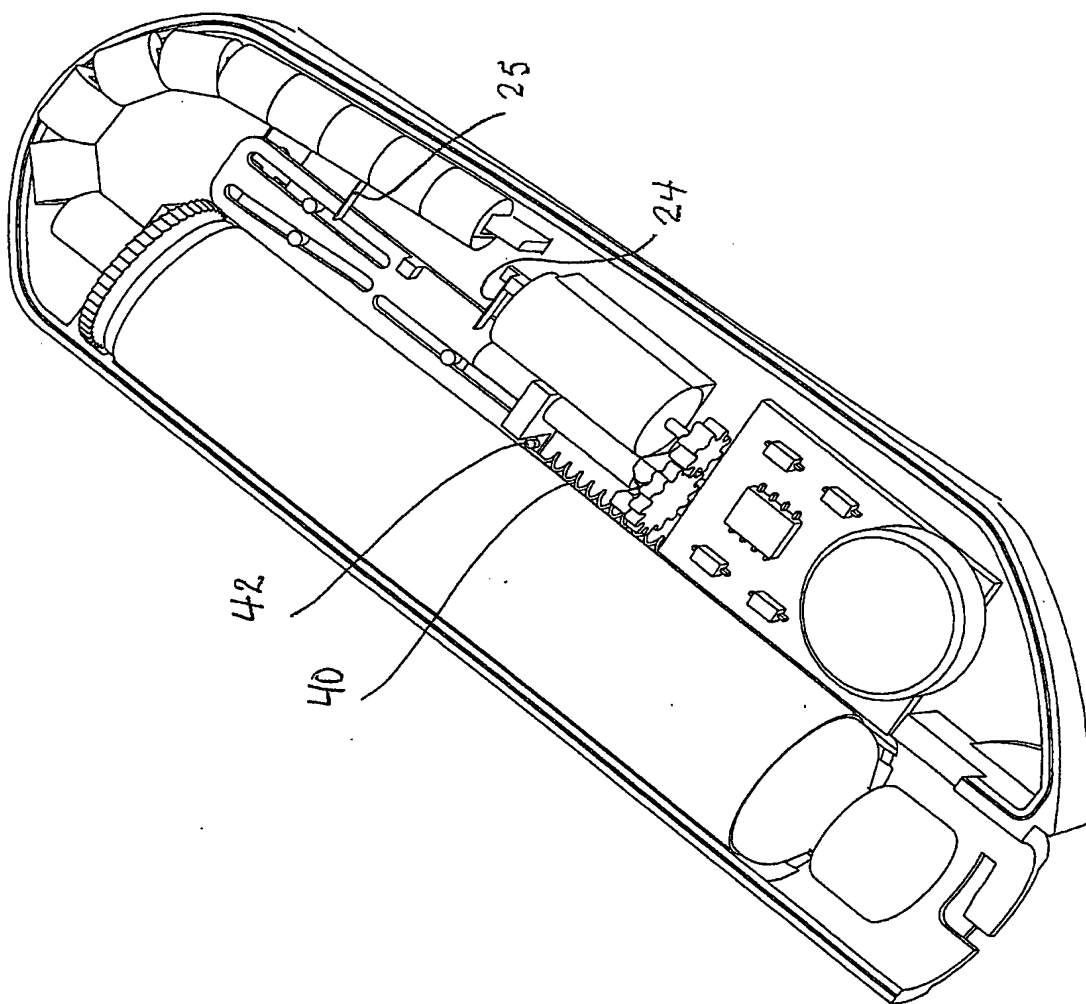


Fig. 5

6/16

Fig. 6



7/16

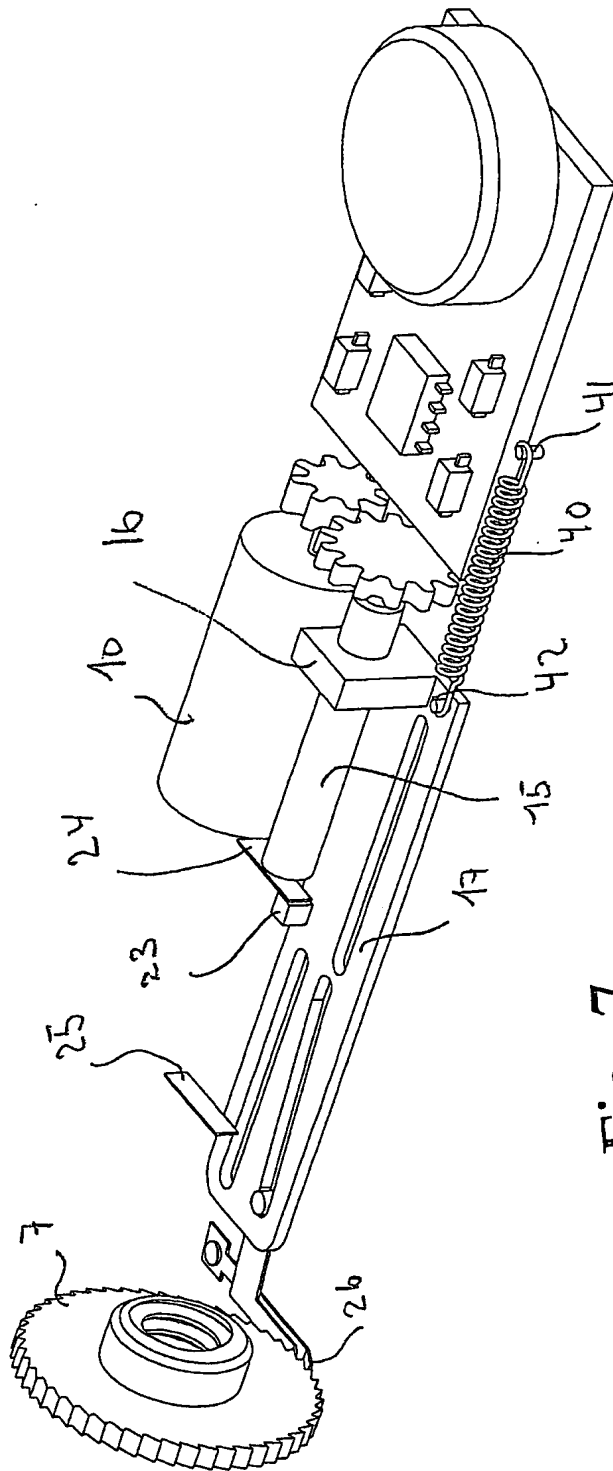


Fig. 7

8/16

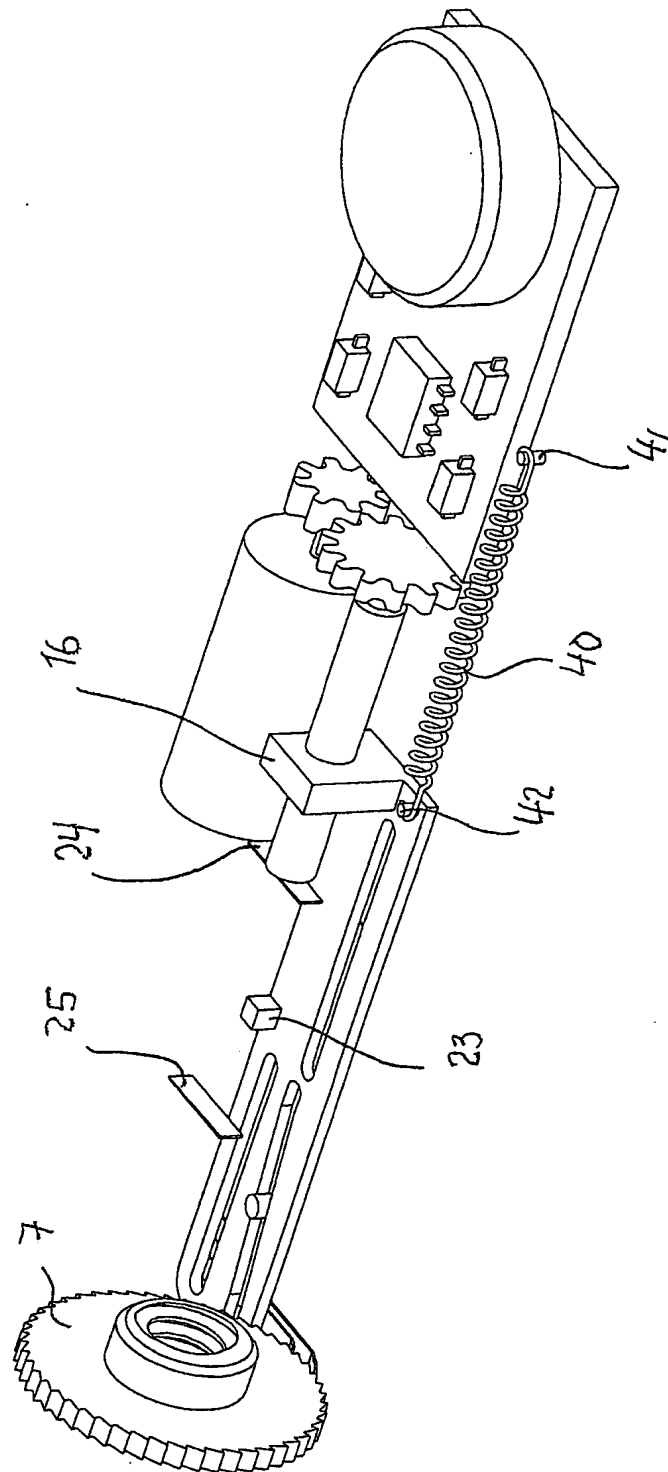


Fig. 8

9/16

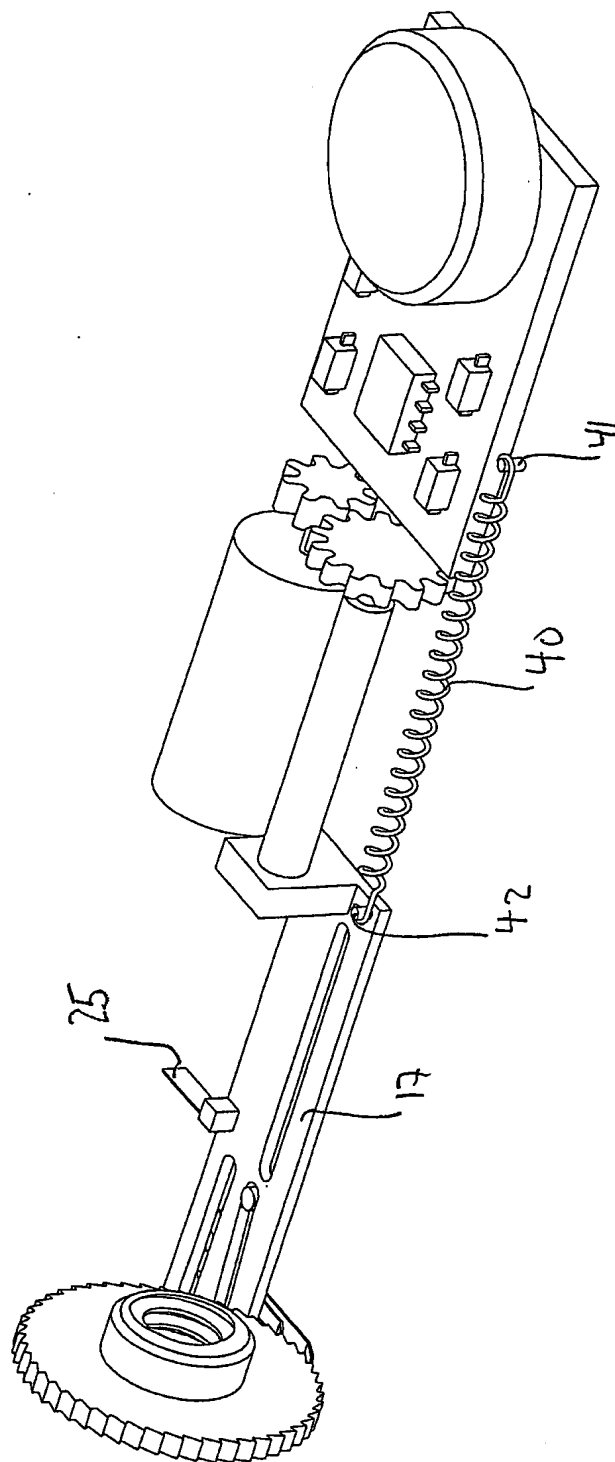


Fig. 9

10/16

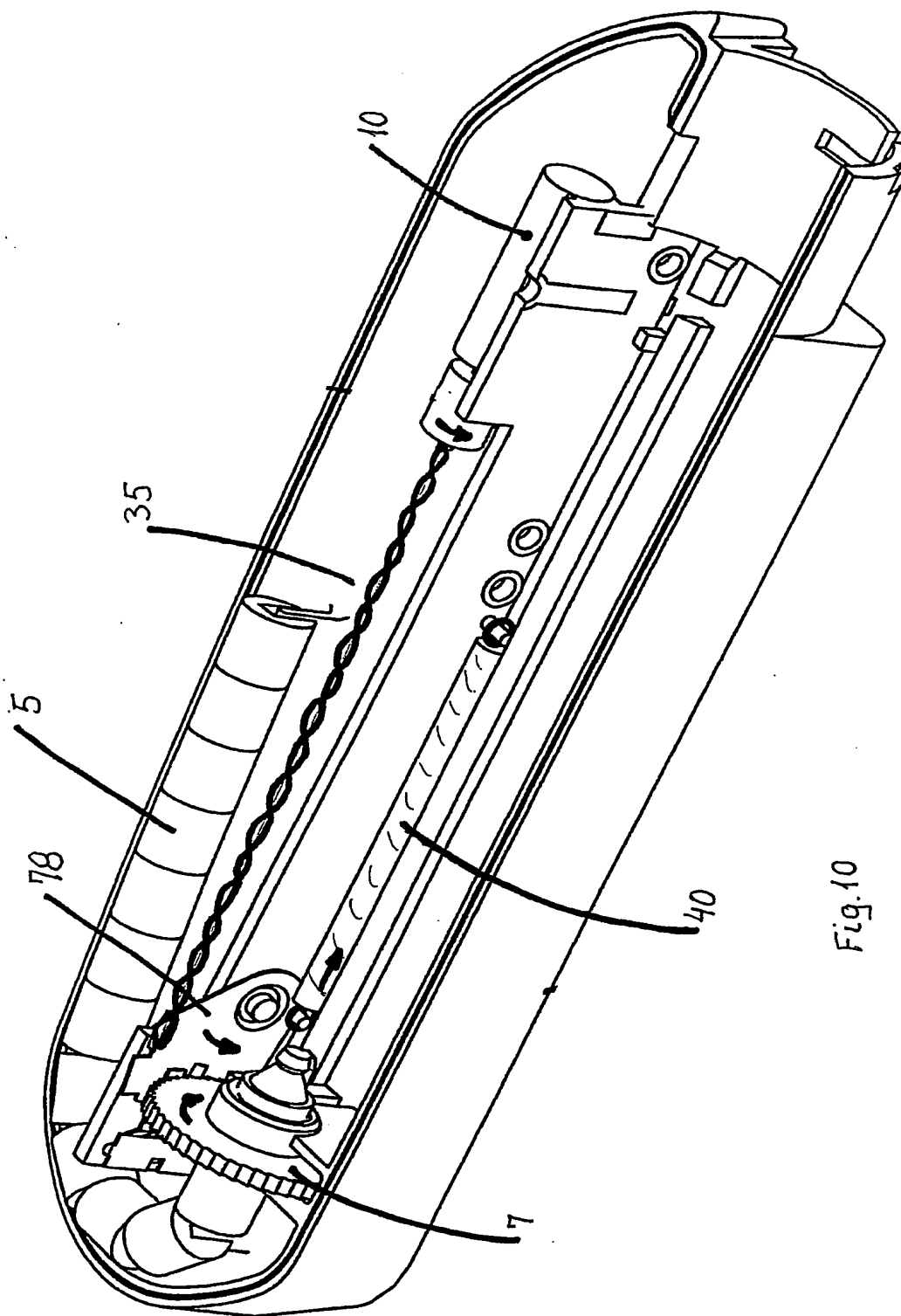
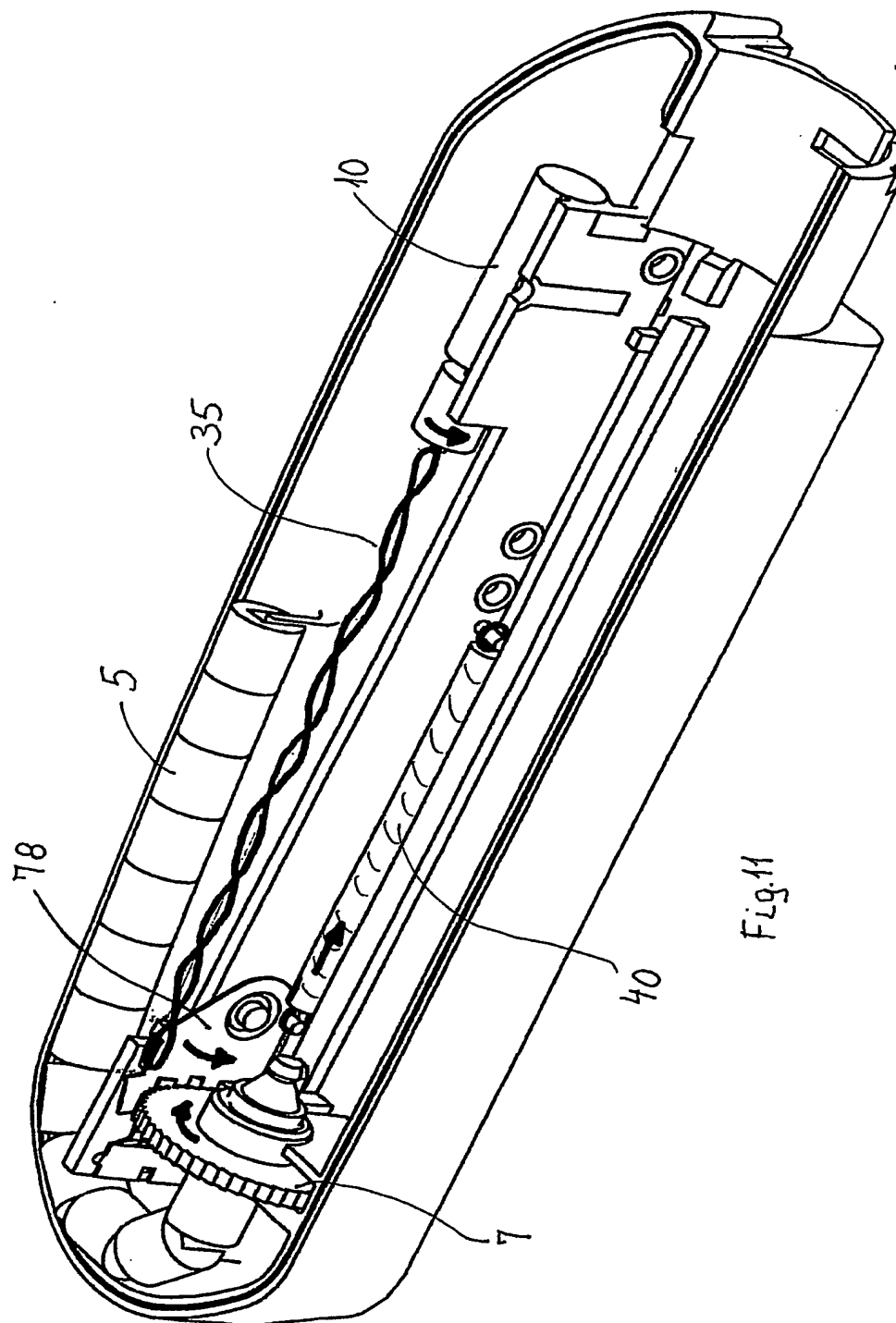


Fig. 10

11/16



12/16

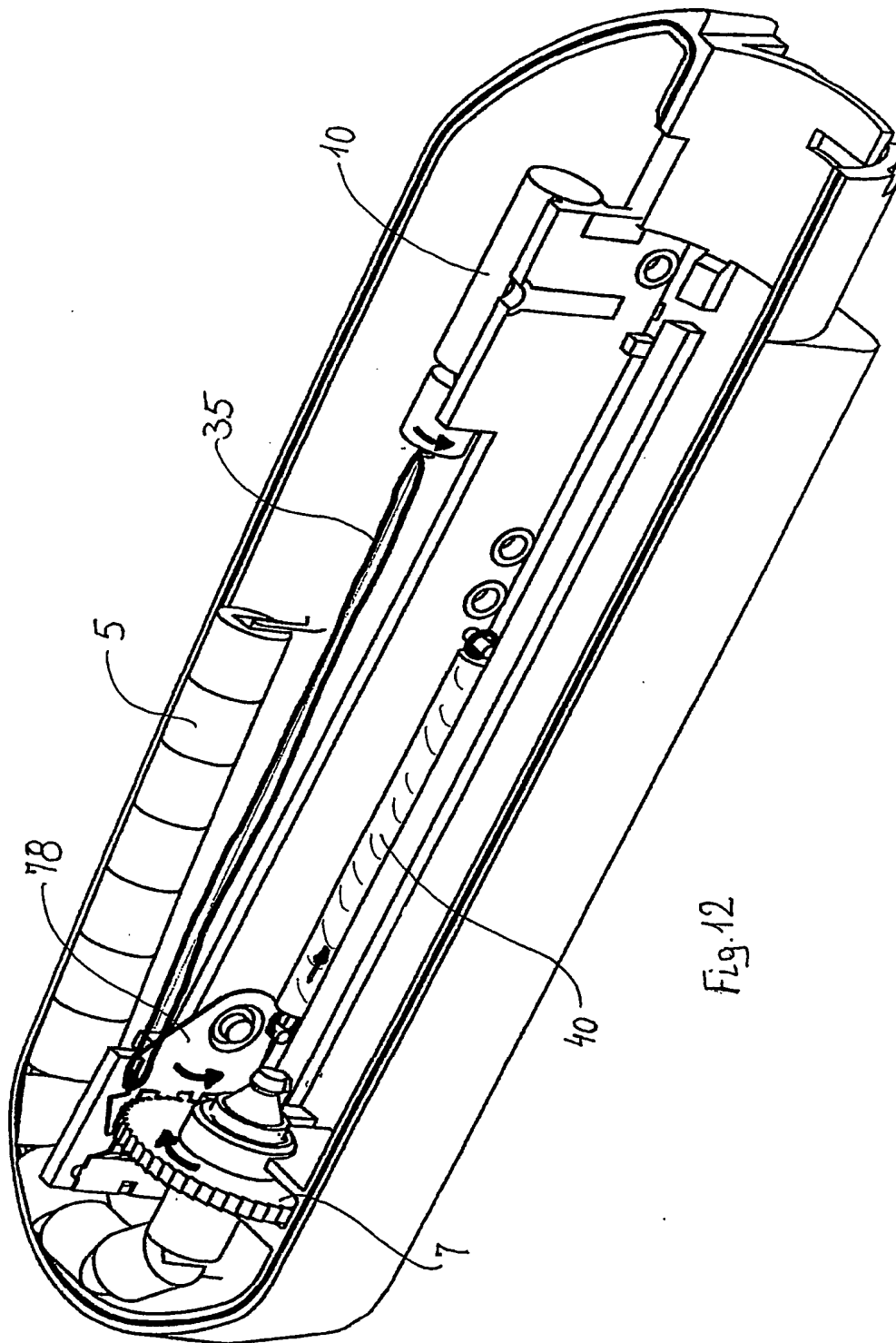


Fig. 12

13/16

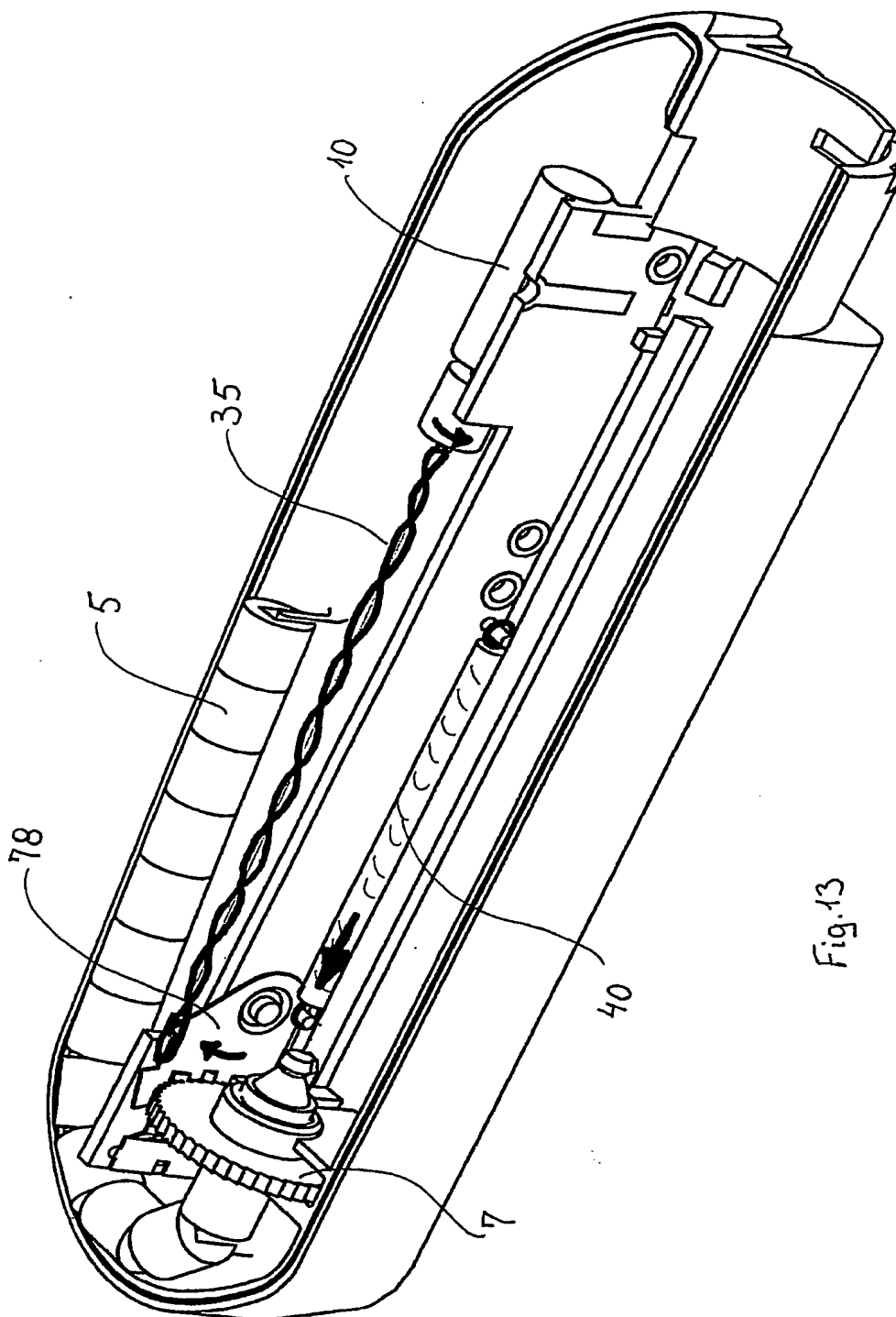
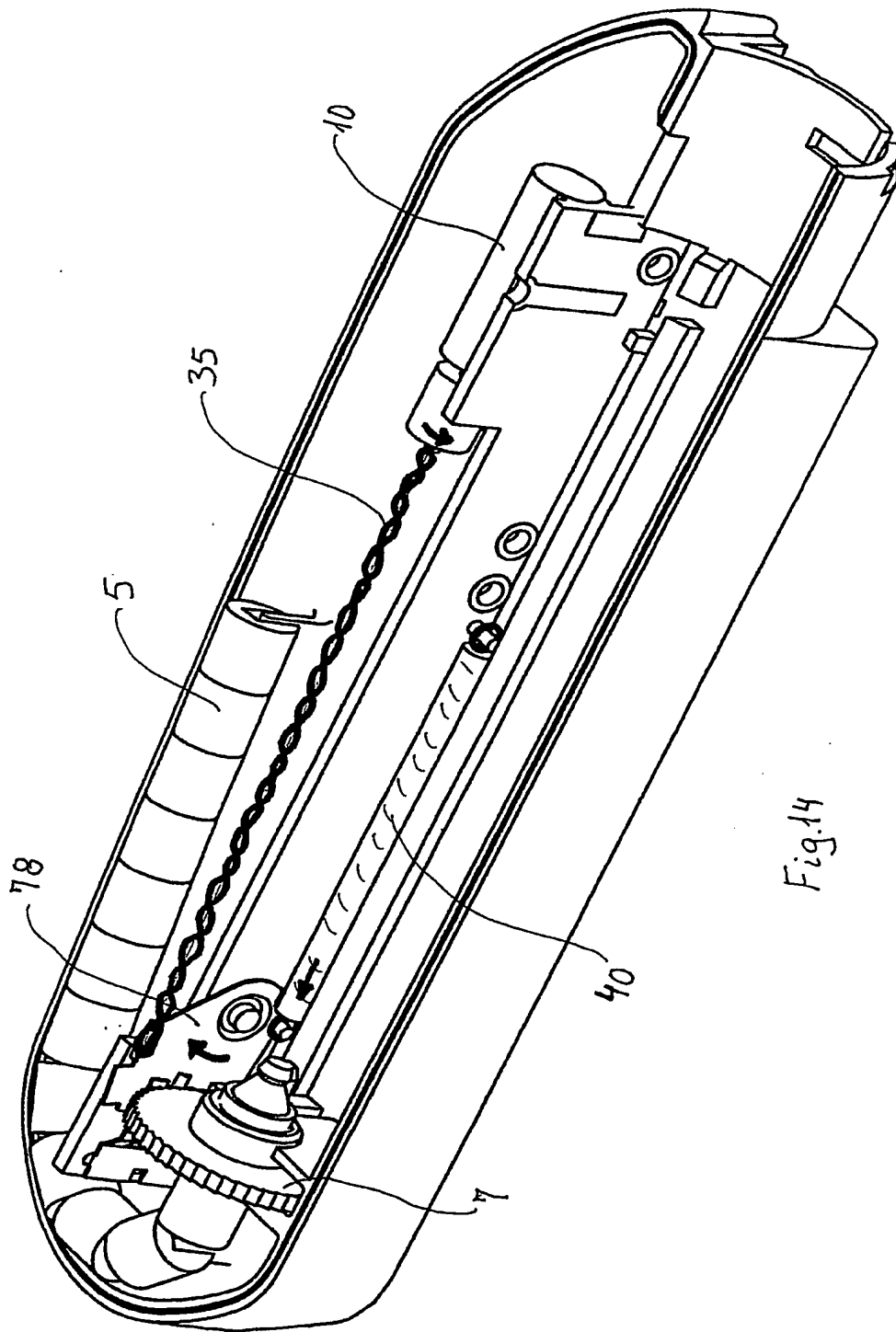


Fig. 13

14/16



15/16

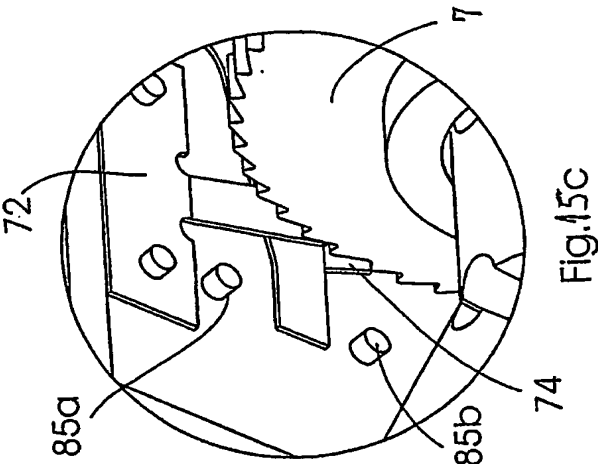


Fig. 15c

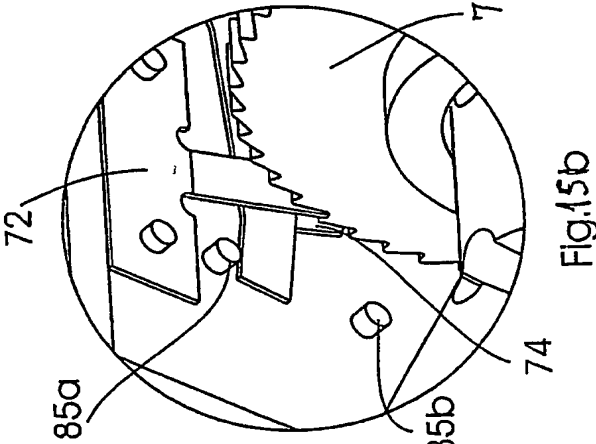


Fig. 15b

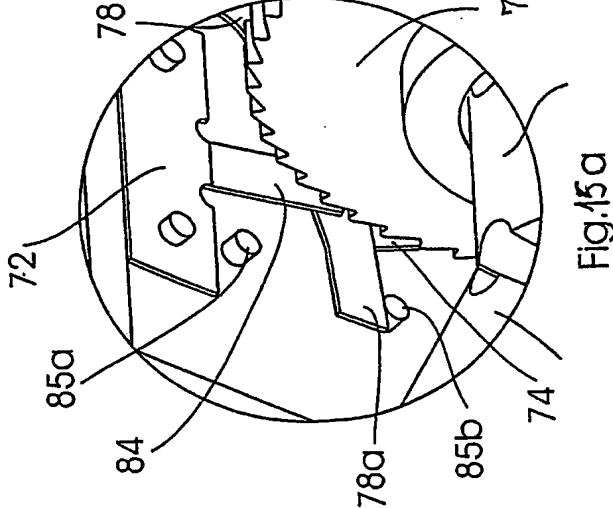
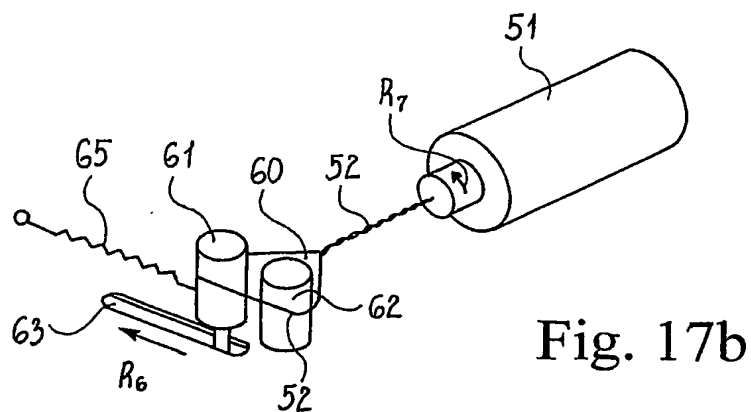
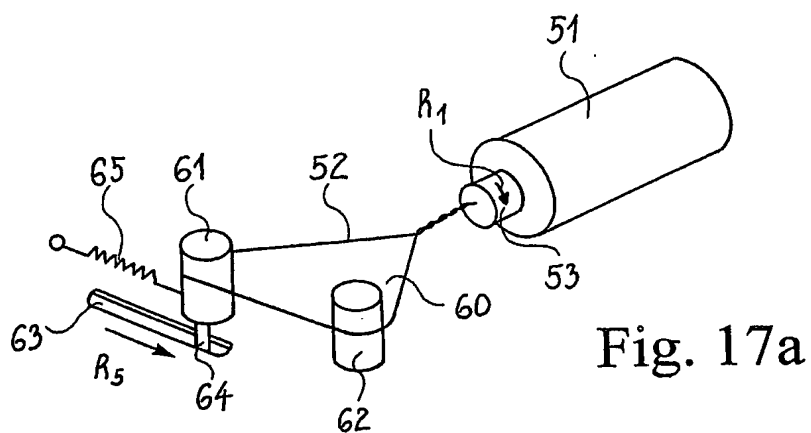
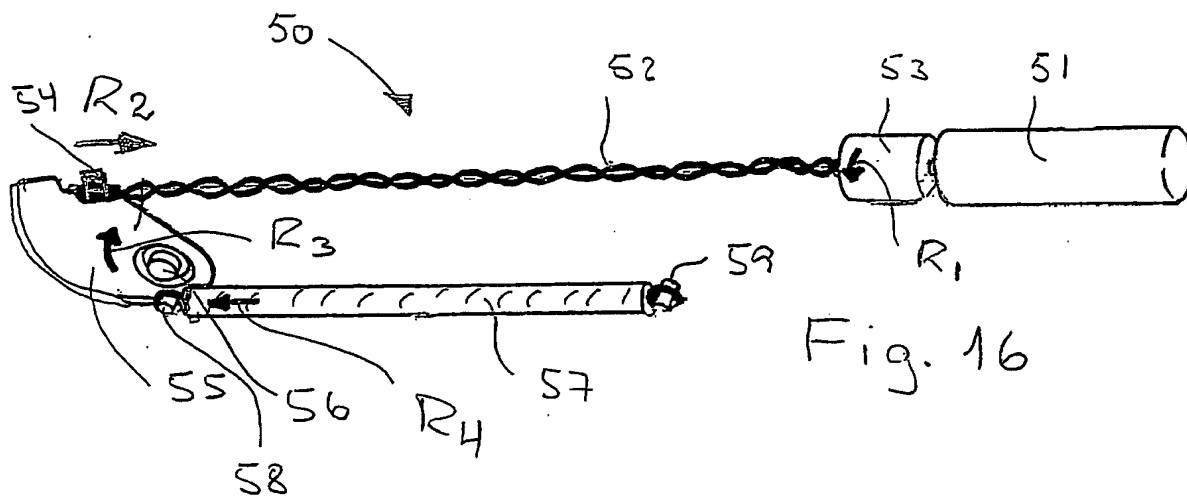


Fig. 15a

16/16



INTERNATIONAL SEARCH REPORT

International application No

PCT/DK2006/000195

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61M5/142

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 747 701 A (LINES BROS. LIMITED) 11 April 1956 (1956-04-11) the whole document	1-6
Y	US 2002/004651 A1 (LJUNGGREEN HENRIK ET AL) 10 January 2002 (2002-01-10) paragraph [0020] - paragraph [0021]; figures 1,2	8
Y	US 2003/199825 A1 (FLAHERTY J. CHRISTOPHER) 23 October 2003 (2003-10-23) abstract; figures	8
P, X	WO 2005/072795 A (M 2 MEDICAL A/S; MERNOEE, MORTEN) 11 August 2005 (2005-08-11) abstract; figures	1-6, 8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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- *P* document published prior to the international filing date but later than the priority date claimed

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- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
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Date of the actual completion of the international search

20 July 2006

Date of mailing of the international search report

23/08/2006

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Authorized officer

Ehrsam, F

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK2006/000195

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 7
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/DK2006/000195

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